THOR'S HAMMER

to crush materials at 1 million atmospheres

Novel features may influence eventual Z-machine rebuild

By Neal Singer

A new star is rising in Area 4. Its name is Thor, its aim is to study materials at extreme pressures, and its novel features may foreshadow future renovations in Z, the world's largest and most powerful pulsed-power accelerator.

Z is a mainstay in Sandia's stockpile stewardship efforts. It is also Sandia's lead machine in the race for peacetime nuclear fusion and premier in creating research conditions mimicking the cores of planets and interiors of stars.

The completed Thor will be smaller and less powerful than Z — 2,000 rather than 10,000 square feet, 100 kilojoules instead of 20 megajoules — but has improvements in design befitting a next-generation accelerator.

The immediate benefit of the new machine is that it will achieve up to five experiments daily, investigating materials by means of its electrically pulse-generated magnetic fields. This will reduce scheduling problems on overbooked Z, which currently can fire only once daily.

More opportunities to test ideas

"Thor will reach about one million atmospheres of pressure, far less than Z's five million," says David Reisman (1651), the lead theoretical physicist of the Thor project, "but that's still relevant. Earth's core is at one million atmospheres, so Thor can perform many geophysics experiments."

Furthermore, because Thor can fire so frequently — less hardware damage per shot requires fewer technicians and enables more rapid rebooting — researchers will have many more opportunities to test an idea, David says.

Thor also will be used develop experiments for Z, as well as a novel X-ray diagnostic that will probe the atomic structure of materials under extreme pressure. "It would be prohibitive to develop such an advanced diagnostic first on Z. Experiments there are fewer and much more expensive," says David.

More at stake

But there's more at stake here than rapidity of firing or even new diagnostics.

There's testing the efficiency of a radically different accelerator design.

Z's design includes 36 massive capacitor banks called

(Continued on page 5)

MAKING READY FOR THOR — Sandia tech Eric Breden (1651) terminates a transmission cable for installation on the silver disk that is the new pulsed-power machine's central powerflow assembly. (Photo by Randy Montoya)

Inside . . .

Exceptional service in the national interest

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Sandia wins five R&D 100 Awards

. . . and a 'green technology' gold award

SANDIA RESEARCHER SUSAN REMPE discusses the CO_2 Memzyme with UNM's Ying-Bing Jiang, right, and a colleague.

By Neal Singer

Competing in an international pool of universities, corporations, and government labs, Sandia researchers captured five R&D 100 Awards this year. One entry also won the R&D 100's "Green Technology Special Recognition Gold Award."

R&D Magazine presents the awards each year to researchers whom its editors and independent judging panels determine have developed the year's 100 most outstanding advances in applied technologies.

The awards, with their focus on practical impact rather than pure research, reward entrants on their products' design, development, testing, and production, and were dubbed "the Oscars of invention" by former *Chicago Tribune* science writer Jon Van.

Sandia's winning entries:

CO_2 Memzyme is an ultra-thin membrane that is the first cost-effective technology for carbon dioxide separation and capture to meet and exceed DOE targets for helping to reduce the threat of climate change. This invention also won the R&D 100 contest's Green Technology Special Recognition Gold Award. Principal investigators (PIs): Susan Rempe (8635), Jeff Brinker (1000), and University of New Mexico research associate professor Ying-Bing Jiang. Sandia's Laboratory Directed Research and Development (LDRD) office provided early development money for this project; funding also provided by DOE Basic Energy Sciences and the Air Force Office of Scientific Research.

LED Pulser uses light-emitting diodes instead of expensive lasers to provide high-brightness, rapidly pulsed, multicolor light for scientific, industrial, or commercial uses. The Pulser's small LED source permits better ignition detection via high-speed imaging and already has resulted in better understanding of injection, combustion, and emissions formation in diesel engines. The work was supported by DOE's vehicle technology office. PI: Chris Carlen (8362)

ICID, or Integrated Circuit Identification authenticates integrated circuits, detects counterfeit electronics, and verifies individuals' identities and their transactions using a unique device signature and cryptographically secure challenge-response protocol. PIs: Jason Hamlet (5627), Todd Bauer (1746), Lyndon Pierson (emeritus). Technology development was funded by Sandia LDRD.

Lightweight Distributed Metric Service (LDMS) monitoring software provides detailed awareness of the system-wide performance of high performance computers and applications in production environments. PIs: Jim Brandt, Ann Gentile, and Benjamin Allan (all 9328) and Tom Tucker, Narate Taerat, and Nichamon Naksinehaboon (all from Open Grid Computing Inc. in Austin, Texas). The work was funded by DOE. Early funding was provided by LDRD.

6.5kV Enhancement-Mode Silicon Carbide JFET Switch: A low-loss power switch based on a novel silicon carbide junction field-effect transistor will improve the efficiency of next-generation power conversion systems used in energy storage, renewable energy, and military applications, as well as data center power distributions. Sandia PI: Stan Atcitty (6111) in collaboration with United Silicon Carbide Inc. and DOE.

The awards were announced in Las Vegas Nov. 13.

SANDIA R&D 100 WINNER Stan Atcitty, right, discusses power conversion with Chris Dries, left, and John Hostetler of United Silicon Carbide Inc.

That's that

Tired of having to type out answers to those pesky emails that flood your inbox? Google is here to help. The innovative thinkers in Mountain View, the folks behind Google Glass, have come up with a new technology called "Smart Reply" that they're rolling out as a G-Mail feature.

The idea is that by using some very smart and sophisticated AI and auto-learning algorithms Smart Reply analyzes your incoming mail and proposes three short answers. Instead of having to actually type out a response, you simply click on a choice that says something like "See you soon," or "I'm working on it." Not timeless prose, but I guess it gets the job done. And to be fair, Smart Reply is designed for use on mobile platforms where you're not likely to type an answer much longer than a few words anyway.

Sure the technology is limited now, but it got me thinking: How far away are we from a time when Smart Reply or its direct descendent will be able to not just analyze thousand-word articles, but reply in kind with perfect grammar and syntax? I suspect it'll happen sooner rather than later. No less an expert on technology trends than Mark Zuckerberg, the Facebook billionaire, says in an item I saw today that within a decade Facebook will be better than humans at a lot of things we now consider the exclusive domain of our own species.

Maybe so. But doesn't Zuckerberg's prediction depend on what you mean by "better?" Will there ever be an automated response system that is "better" than a lively exchange between two very-much-alive and engaged human beings? Will it ever match, for example, the wit of a correspondence between Winston Churchill and playwright George Bernard Shaw? In one reported exchange, Shaw sent Churchill a note that read, "Here are two tickets for the opening of my play. Bring a friend — if you have one." To which Churchill replied, "Cannot possibly attend first night; will attend second night — if there is one." Now *that* was a Smart Reply!

* * *

Automated replies are nothing new, of course. Smart Reply is just a neat new wrinkle on the old boilerplate form letter concept that's been around since . . . well, probably since words were first carved in stone. We get form letters all the time. I mean, there must be a Christmas letter generator out there somewhere that asks you to plug in the names of your spouse, your kids, and your dog and then spits out a cheerful missive along the lines of:

"Our Preston won the Nobel Prize in Physics — yes, even as a high school junior at Andover — and Sloan is now leading the Barrington Foundation's literacy program in Nambutu. Gwendolyn and I spent most of the year trekking in Pashman, where we were able to help in the earthquake relief effort. And it won't surprise any of you to hear that Harley won Best in Show at Westminster — yes, again. All in all, we just want you to know that we had a way better year than you did. Happy Holidays! The Cadwalader-Smythes."

* * *

Working in the IPOC building is a constant adventure. A while back I wrote about our mouse invasion. Seems the little critters were infesting a lot of people's drawers and — like the drunken cook in the song *Sloop John B* — eating up all of their corn. Our facility manager and his team, working with the building owner, were right on top of the situation and eventually cleared up the problem with no muss and no fuss — for us. For the mice, not so much.

But as the late, great comedian Gilda Radner used to say, "It's always something!" Now, with the creatures from the mouse lagoon beaten back to their field headquarters, we have a new nemesis, as noted on a poster in one of our stairwells: "Be careful going up or down the stairs. A bead necklace broke earlier and there may be some rogue beads."

I've had to watch out for lots of things in my life, but "rogue beads" is a new one on me.

I appreciate the heads-up poster; This could be a safety issue and falling down a flight of stairs is nothing to laugh at. And I am grateful for small favors: After all, had the necklace mishap involved a Goth or biker employee, the warning might have been about rogue razor blades.

See you next time.

— Bill Murphy (MS 1468, 505-845-0845, wtmurph@sandia.gov)

Employees, retirees . . .

OPM now mailing notifications to homes

The US Office of Personnel Management (OPM) says its contractor, Theft Guard Solutions LLC, also known as ID Experts, is mailing notification letters to 21.5 million federal employees and contractors whose clearance information was stolen in the massive cyberattack that OPM announced on June 4. The notification process, which began Oct. 1, could take up to 12 weeks to complete.

The OPM data breach involves the records of individuals who underwent a background check for a government security clearance in the year 2000 or later. Almost all current Sandia employees are likely affected, as are retirees who underwent reinvestigations in the past 15 years.

In her announcement, OPM Director Beth Cobert said the letters will describe free services for identity theft protection and credit monitoring that will be provided to those whose personal information was stolen, along with their dependent minor children. The letters, sent via US mail, will provide personal identification numbers that individuals must use to log in to a website for MyIDCare, the protection service.

OPM and its contractor will not send emails and will not "contact you to confirm any personal information. If you are contacted by anyone asking for your personal information in relation to compromised data or credit monitoring services, do not provide it," Cobert wrote.

OPM also announced that 5.6 million of those affected had their fingerprints stolen, and will be informed of that in the letters.

Cobert noted it will take considerable time to deliver all letters, and projected it could take until the end of the year to notify everyone affected.

More information is on the OPM website at www.opm.gov/cybersecurity.

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LOCKHEED MARTIN

Sandia turkey drive aids needy neighbors

SANDIA'S ANNUAL HOLIDAY GIVING TRADITIONS began Nov. 17 with Take a Turkey to Work Day. This year, Sandia employees donated more than 2,500 lbs. of turkey to Roadrunner Food Bank. The turkeys will find their way to the tables of hungry families during the winter season. In the photo above from 2013, Tommie Kuykendall (10597), left, and Sandra Portlock (1400) corralled the frozen turkeys for pick-up by Sandia's Logistics folks, who transported them to the main Roadrunner Food Bank facility. This year again, volunteers staffed several pickup locations around the Labs to collect the donated birds. (Photo by Randy Montoya)

Bringing it home

Katrina Groth and Ethan Hecht win inaugural Robert Schefer Best Paper award

By Patti Koning

In October, Sandia scientists Katrina Groth (6231) and Ethan Hecht (8367) were recognized at the IA-HySafe International Conference on Hydrogen Safety (ICHS) with the inaugural Robert Schefer Best Paper award.

The award honors the late Robert (Bob) Schefer, formerly a researcher at Sandia's Combustion Research Facility, for his contributions to characterization and understanding of the hydrogen behavior when unintentionally released at conditions relevant to hydrogen fueling infrastructure. Bob's work has been key to the validation of numerical simulations of hydrogen behavior and the development of analytical models that capture the basic physics of these behaviors for use in codes and standards.

"Bob's turbulent combustion research was critical to successful computer modeling of hydrogen releases from day one."

Katrina and Ethan's paper, "HyRAM: A Methodology and Toolkit for Quantitative Risk Assessment of Hydrogen System" was chosen from 167 submissions to the conference. The selection panel included seven technical experts from the ICHS scientific committee representing the countries of China, Germany, Ireland, Japan, the Netherlands, the United Kingdom, and the United States.

Katrina and Ethan were honored at a ceremony held at Sandia on Nov. 19. In attendance were Bob's widow, Jade; Sunita Satyapal, director of the DOE Fuel Cell Technologies office (FCTO); Erika Sutherland, technology development manager, FCTO; Will James, Safety, Codes, and Standards project manager, FCTO; Bob's Sandia colleagues; and representatives from the broader hydrogen safety community. FCTO's Safety, Codes and Standards project funds the risk and the hydrogen behavior work at Sandia, including Bob's research, and now that of Katrina and Ethan.

"Bob's turbulent combustion research was critical to successful computer modeling of hydrogen releases from day one. The entire hydrogen codes and standards community continues to reference his work, as does the scientific community in hydrogen combustion," says Art Pontau (8360), senior manager of Combustion and Industrial Technology at Sandia.

Data still used extensively

Bob, a mechanical engineer, joined Sandia in 1981 and worked in thermofluidics, combustion physics, and reacting flow as well as hydrogen and combustion technology until his death in 2010. His research on turbulent combustion provided data that continues to be used extensively to validate models of hydrogen releases, which are needed to support the deployment of hydrogen refueling infrastructure and code development for hydrogen safety.

Katrina and Ethan's paper describes the Hydrogen Risk Assessment Model (HyRAM), a methodology and accompanying software toolkit that integrates the risk-assessment process with the detailed physics of hydrogen behavior. HyRAM enables scientifically based codes and standards for hydrogen technologies and infrastructure that are consistent, logical and defensible. The toolkit also facilitates risk-informed engineering design and decision-making processes.

"To calculate risk, HyRAM uses the physical models validated by Bob Schefer's data," says Jay Keller, a former hydrogen program manager at Sandia, now president of Zero Carbon Energy Solutions. "It's very fitting that the inaugural Bob Schefer award recognizes work that was made possible by his significant contributions to the international community for hydrogen codes and standards."

"IT JUST BLOWS ME OUT OF MY SHOES to meet these two amazing young people who are following in my husband's footsteps," says Jade Schefer, wife of the late Robert Schefer, of Katrina Groth, left, and Ethan Hecht, inaugural recipients of the ICHS Robert Schefer Best Paper award. (Photo by Randy Wong)

Sandia CaliforniaNews

Exceptional service in the national interest

Jackie Chen receives DOE INCITE award

Jackie Chen (8351), a distinguished member of technical staff at Sandia's Combustion Research Facility, has received an Innovative and Novel Computational Impact on Theory and Experiment (INCITE) award from DOE's Office of Science.

JACKIE CHEN

Jackie has received 96 million core hours to simulate turbulent combustion processes as they relate to fuel-flexible stationary gas turbines and fuel-efficient clean internal combustion engines using biofuels to simulate fundamental turbulent combustion processes.

The 56 projects that received INCITE awards are aimed at accelerating discovery and innovation to address some of the world's most challenging scientific questions. The projects will share 5.8 billion core hours on America's two most powerful supercomputers dedicated to open science. The diverse projects will advance knowledge in critical areas ranging from sustainable energy technologies to next-generation materials.

The INCITE program promotes transformational advances in science and technology through large allocations of time on state-of-the-art supercomputers. Researchers from academia, government research facilities, and industry received computing time through INCITE. The program was created as the primary means of accessing the DOE Leadership Computing Facilities at Argonne and Oak Ridge national laboratories.

California site honors veterans

COMPANY MEMBERS from the 532nd Combat Support Hospital, including Jose Alves (8511) of Sandia's Protective Force, present the national colors at the California site's Veterans Day event on Nov. 11. Speaking at the event were Div. 8000 VP Marianne Walck along with Sandia President and Laboratories Director Jill Hruby and Div. 4000 VP Mike Hazen, who were visiting for the Fall Leadership meetings. (Photo by Loren Stacks)

Poets at Sandia celebrate and mourn warriors

By Neal Singer

Perhaps because it was almost evening, the 24 people sitting on chairs casually arranged in Sandia's large Thunderbird cafeteria generated an oddly relaxed feeling, like survivors meeting after a battle, as they listened to poets and a flutist put a human face on recent American wars and military actions.

A large American flag, hung from the cafeteria's central support post, showed only 48 stars. It had come into Dante Berry's (2155) family in 1945 and was passed from generation to generation. "I take it out twice a year, but this year, three times," he said of the special event for which he served as host. "It honors the memory of everyone who has served or is serving. Thanks to all veterans."

BENEATH HIS FAMILY'S HERITAGE US FLAG, Dante Berry (R) (2155) addresses the audience at a tribute to veterans in poetry, music, and art that he hosted. To his right, in order, are featured poets Mark Fleisher, Rob Mitchell (4021) and Jim Nye, all former warriors. (Photo by Neal Singer)

The Sandia-sponsored "Tribute to Veterans in Poetry, Music and Art," was held on Tuesday, Nov. 10. It featured poets Mark Fleisher, a former Vietnam combat news reporter; Rob Mitchell (4021), an Iraq combat veteran and founder of the organization "Full Battle Rattle," which uses music as therapy to help vets through post-traumatic stress disorder; and Jim Nye, an Albuquerque attorney and poet who served in Vietnam with the 101st Airborne and 5th Special Forces group.

Other poets also participated and patriotic art was on display.

From honor to horror

The poems and comments ranged from deep feeling to self-protective humor, and from honor to horror.

Curtis Keliiaa (9336) praised "our valiant warriors who fought for the world to be saved," and Sandia photographer Randy Montoya (3651) wrote movingly about a valiant military friend who had passed on: "He stands his watch where eagles soar."

Rob Mitchell read from his writings that he "wondered so many times in that war zone/if I would ever make it home," and, though he seemed physically unscathed after "fighting for those stripes and stars/ if you ask me, I have my scars."

Fleisher said that because of his first-hand experience with rockets and bombs, when invited to participate in a 4th of July celebration at home, he declined because, having experienced the real thing, "I don't do fireworks well." And he said, "Damn the wars but praise the soldiers."

Andi Penner (3654), president of the New Mexico State Poetry Society, wrote about a woman who stops ironing shirts to watch TV attentively as "the dead soldiers' photographs appear/eleven, tonight/each with a name, age, rank, and home town/some, with an incongruous smile."

Among the vivid memories recalled of dust, helicopters, rockets, prayers, broken bodies, and sloshes through mud, Jim Nye added an irreverent note.

"When I got out of the service, I thought I would become human again; instead, I went to law school," quipped the lawyer.

But Nye also recounted the horror of war memories that, without invitation, entered his civilian moments. He put it this way in his poem, EPIPHANY (quoted with author's permission):

At the dinner table I looked up
from my steak to see a figure
in black pajamas slide down the
embankment into the rice paddy and
mother poured a glass of milk
while father talked about going to Paris
in the spring and the muddy water slid
past the nearly submerged
VC and my hand trembled as I
gripped the steak knife.

Arnold Puentes (5012) made prints of his patriotic art work available free, suggesting that donations be made to organizations like Full Battle Rattle.

At meeting's end, Ron Hoskie (48422) played a measured, graceful version of the old spiritual "Amazing Grace." The thin, reedy melody from his wood flute seemed to pull listeners beyond the hum of the cafeteria's large refrigerators into some distant place of quiet reflection. Not an adult stirred while he played.

"Beautiful, very moving," commented Dante, who then sang "*God Bless America*" to close the program.

The meeting was hosted by Sandia and community partners, under the umbrella of the Diversity and Inclusion organization led by Esther Hernandez (3010).

Said Esther, "We sometimes forget the price paid by our veterans."

Sandia honors its veterans

See Veterans Day photos on pages 3, 8.

Slip Simulator credited for 50 percent reduction in related injuries

By Karli Massey

With wetter-than-average conditions forecast, it's time to experiment with how to navigate slippery conditions

Slips, trips, and falls have been one of the leading sources of injuries at Sandia for years, especially during winter. One-third of those injuries are associated with activity-level work (such as falls from ladders or slipping when moving equipment), while the other two-thirds have occurred during hazardous weather conditions and Sandians' normal foot "commute," which can be either cross-campus or across the parking lot.

Since Sandia began offering the Slip Simulator training in December 2012, it has seen a 50 percent decrease in slip, trip, and fall injuries across the Laboratories. In functional areas that are most likely to have those injuries — such as Custodial Services, Logistics, and Protective Force — their numbers have similarly decreased.

"It's great that we have a training tool that demonstrates such effectiveness," says Div. 1000 VP and Chief Technology Officer Rob Leland, who has been a proponent of the Slip Simulator since seeing firsthand the positive results.

"It's an easy and fun way to positively improve the safety of Sandians, and the groups I've gone through the training with have also found it to be a good team-building activity," he says.

The Slip Simulator apparatus is a 10½ -foot-high steel frame suspended over a polished, 20-foot-long tile runway that is three times more slippery than ice. The trainee wears a harness attached to the top of the frame and walks down a 4-foot-wide oiled path in a special shoe fitted with furniture-moving sliders.

NO SLIP-UPS — Lt. Joseph Branch (4237-5) performs a tactical movement on the Slip Simulator using a training weapon while properly harnessed.

Navigating slippery surfaces

Safety engineer Whitney Faust (4122) explains, "The training at the simulator is not about teaching people how to fall, but how to navigate slippery surfaces. The kinetic learning technique helps you learn by doing and encourages mindfulness during wet or icy conditions — whether at work, at home, or out enjoying the outdoors."

Rob compares Slip Simulator training to an experiment. "You're basically testing the consequences of your actions, such as how you step on the slick surface, the effect of different postures, and your response to varying environmental factors. Then, you experience the results."

As of the beginning of this month, nearly 4,000 Sandians have completed the training. About 2,000 were active participants with the other 2,000 participating as observers. Since the program was initiated three years ago, not one person who has completed the course as an active participant has been injured from a slip.

Andres Tabios (42376), training lieutenant for Sandia's Protective Force, says the Slip Simulator provides an added skill for officers. "Many of us can get complacent and think that we've done this for years or think that our boots will keep us from slipping, but I've been able to see how this training has really enhanced our safety during hazardous conditions," he says.

Protective Force officers are exposed to all kinds of weather, whether snowy nights or rainy days. "Our officers are now more sure-footed and now know how to prevent injuries in slippery conditions."

The 90-minute training is often used as a team-building activity. "Our trainers encourage you to have fun. Plus, studies have shown that even observers are able to learn from the activity," Whitney says. However, for those who would like one-on-one attention, individuals can also schedule a session at the simulator.

Slippery Conditions Ahead

According to the National Oceanic and Atmospheric Administration Climate Prediction Center's winter outlook, this year's El Niño — among the strongest on record — is expected to translate into wetter-than-average conditions in some regions of the country. Some are calling it the Godzilla El Niño. From central and southern California, across New Mexico and Texas, and through to Florida, residents will likely experience a monster of a winter.

"I encourage people to try the Slip Simulator for themselves," says Rob. "It's an experiential learning tool that has been shown to be effective here at Sandia."

Thor

(Continued from page 1)

Marx generators (each is 8 ft. x 8 ft. in cross-section, 12 ft. tall). These release electrical energy through transmission lines as thick as a horse's girth, followed by complicated switching to shorten its electrical pulse by an order of magnitude, from one microsecond to 100 nanoseconds. This temporal reduction is necessary to greatly increase the pulse's impact on a target.

Thor ultimately will be built of much smaller but many more capacitors, segregated by twos in one-cubic-foot containers called bricks. Each capacitor pair will be combined with its own small switch that, when engaged, will immediately discharge current in a 100-nanosecond pulse, without the energy losses inevitable when compressing a long pulse. And each brick's dedicated cables of far smaller diameters won't need the expensive water and oil baths that shield Z's massive current-bearing transmission lines from shorting out.

This change in design — from a few massive components to many small ones — could be considered analogous to the change in computing decades earlier that replaced a single, extremely powerful computer chip with many relatively simple computing chips working in unison, or, to the evolution of computers that replaced several high-voltage vacuum tubes with a much larger number of low-voltage solid-state switches.

SANDIA TECHNICIAN Tommy Mulville (1651) installs a gas exhaust line for a switch at Thor's brick tower racks. In the background, beyond the intermediate support towers, technician Eric Breden (1651) makes ready an electrical cable for insertion in the central power flow assembly. (Photo by Randy Montoya)

Finer control of pulses

Among other advantages, the new architecture allows finer control of the electrical pulses sent to interrogate materials, similar to the way a pianist playing separate notes elicits a more satisfactory response from an audience than a single crash of chords. Says David, "Individual cables from each brick separate our signals. Then, by combining them in any manner we choose, we can tailor very precise current pulses."

Tailored pulse shapes are needed to successfully interrogate a variety of materials to avoid shocks that would force them to change state. "We want the material to stay in its solid state as we pass through phase boundaries reached as pressures increase," he says. "That way, we can more easily test the compressed matter. If we shock the material, it becomes a hot liquid and doesn't give us information."

Thor's advantage over Z in such testing, says David, is that because each capacitor's transit time is not only controllable to the nanosecond level but isolated from the other capacitors, "in relatively few seconds on a computer, we can determine the shape of the pulse that will produce a desired compression curve, whereas it takes days to determine how to create the ideal pulse shape for a Z experiment."

> *"We shouldn't ever build a Marx generator-driven system again. That's a 90-year-old technology."*
>
> **— Sandia researcher Mike Cuneo**

There are other advantages to Thor's architecture. Because current is subdivided among so many more units, Thor's 200-kilovolt switches are expected to last for many thousands of shots, an order of magnitude larger than the life times of Z's 6.6-megavolt switches, says senior manager Mike Cuneo (1650).

Everything depends upon adding bricks. Thor, for which materials were assembled this year, is expected to achieve two intermediate stages in 2016. These will comprise 24 bricks (Thor 24) and 48 bricks (Thor 48). "These are 'first-light' machines that will be used for initial experiments and validation," says David.

Could play a part in Z renovation

Then, due to more efficient switches and lesser interference from rebounding currents, Thor 144, when completed, is expected to be 40 times more efficient than Z in magnetically generated pressure. Technically, Thor 144 will achieve one megabar of pressure with 100 kilo-Joules (which works out to 10 Mbar/MJ) while Z achieves 5 megabars with 20 MJ capacity (which works out to 0.25 Mbar/MJ).

Thus it's not surprising that there's thought that the new architecture may play a part when it comes time to renovate Z itself.

Thor's bricks are a fourth-generation descendant of a device jointly developed by the Institute of High-Current Electronics (Tomsk, Russia) and Sandia called a linear transformer driver (LTD). The original LTD bricks had no cables to separate outputs, but instead were linked together to add voltage as well as current. (Because Thor's bricks are isolated from each other, they add current but not voltage.)

High-yield fusion?

According to manager Bill Stygar (1651), more powerful LTD versions of Z ultimately could bring about thermonuclear ignition and even high-yield fusion. Ignition would be achieved when the fusion target driven by the machine releases more energy in fusion than the electrical energy delivered by the machine to the target. High yield would be achieved when the fusion energy released exceeds the energy initially stored by the machine's capacitors.

LTDs, says Mike Cuneo, "may be the simplest, most reliable, and efficient pulsed-power architectures to make plasmas that can potentially ignite and burn. We shouldn't ever build a Marx generator-driven system again. That's a 90-year-old technology."

The academic community also is interested in Thor's architecture. "Part of the motivation for Thor was to develop affordable and compact machines that could be operated at universities," says David. Institutions that have expressed interest include Cornell University, University of California San Diego, Imperial College London, and the Carnegie Institution.

A paper published Sept. 9 in *Physical Review Special Topics – Accelerators and Beams*, co-authored by David, lead electrical engineer Brian Stoltzfus (1651), Bill, lead mechanical engineer Kevin Austin (1657), and colleagues, outlined Sandia's plan for Thor. A later paper, led by Bill and in preparation for publishing in the same journal, discusses the possibility of building next-generation LTD-powered accelerators to achieve ignition and high-yield fusion.

Thor's theoretical design was supported by Sandia's Laboratory Directed Research and Development office; later engineering details and hardware by NNSA's Science Campaign.

Supercomputer benchmark developed by Mike Heroux gains adherents

By Neal Singer

The fourth semi-annual supercomputer ratings determined by a software program designed and developed by Mike Heroux (1426), in collaboration with Jack Dongarra and Piotr Luszczek from the University of Tennessee, continues to gain traction in the high-performance computing community. The new ratings were released Nov. 18 at SC15, one of the world's premier supercomputing meetings.

MIKE HEROUX

The emerging tool, termed the High Performance Conjugate Gradients (HPCG) benchmark, was executed on more than 60 supercomputer entries for the current round, up from the initial 15 competitors 18 months ago.

"HPCG is designed to complement the traditional High Performance Linpack (HPL) benchmark used as the official metric for ranking the top 500 systems," says Mike. "Currently, the pair of numbers provided by HPCG and HPL act as bookends on the performance spectrum of a given system."

While HPL tests supercomputer speed in solving relatively straightforward problems, HPCG's more complex criteria test characteristics such as high-performance interconnects, memory systems, and fine-grain cooperative threading that are important to a broad set of applications.

A lot of work ahead

"Many benchmarks have been proposed as complements or even replacements for Linpack," says Mike. "We have had more success than previous efforts. But there is still a lot of work to keep the effort going."

The current list contains the same entries as many of the top 50 systems from Linpack's TOP500 but exhibits a significant shuffling of HPL rankings, indicating that HPCG features are stressing different system characteristics.

Asked what causes supercomputer manufacturers and users to gravitate toward HPCG as a useful test, Mike says, "Only time will tell. All major vendor computing companies have invested heavily in optimizing our benchmark. All participating system owners have dedicated machine time to make runs. These investments are the strongest confirmation that we have developed something useful."

As a case in point, the new Los Alamos/Sandia supercomputer Trinity, listed sixth fastest in the current Linpack ratings, was bumped up to fourth by HPCG.

Says Mike, "I believe this indicates that HPCG is a better representative for workloads that NNSA cares about. It also confirms the NNSA choice to build a system — Trinity — that is more about balance than getting the best HPL result."

Mileposts

New Mexico photos by Michelle Fleming

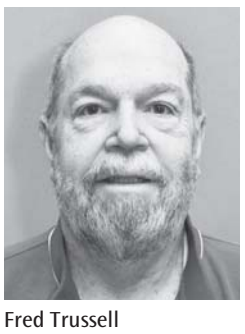
Margie Box
45 9540

Paul Attermeier
40 5566

Rita M. Baca
40 10248

Bert Tate
40 5339

Gary Froehlich
35 5345



Fred Trussell
35 412

Eunice Young
35 5560

Shawn Kerr
30 2662

Leonard Martinez
30 1353

Brad Nation
30 5631

Grace Thompson
30 256

Bob Weir
30 5417

Doug Weiss
30 2122

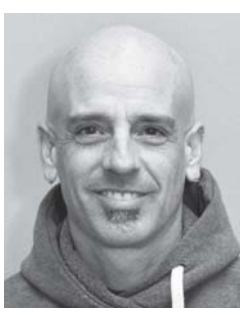
Patty Zamora
30 3652

Kathy Alam
25 2555

Michelle Barela
25 10621

Eric Burns
25 1741

Tom Corbet
25 6924



Joe Ehasz
25 2635

Valerie Mascarenas
25 10626

Stephanie Perea
25 6530

Rekha Rao
25 1516

Matt Umstead
25 4254

Ron Brightwell
20 1423

Samuel Felix
20 10679

Julie Ludwig
20 10657

Tom Russo
20 1355

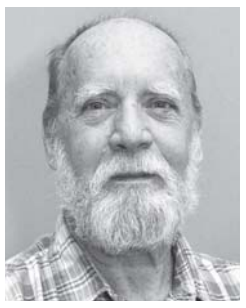
George Burns
15 1725

Jonathan Campbell
15 1123

Theresa Chacon
15 10676

Mario Delgado
15 2159

Christopher Gibson
15 5353

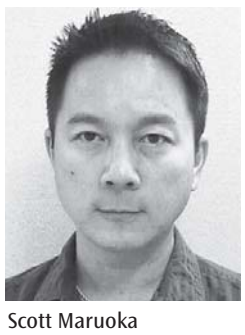


Kenn Greives
15 5444

Kathryn Hanselmann
15 1932

Monica Lovato-Padilla
15 6000

Kenneth Martinez-Eubanks
15 4237



Scott Maruoka
15 5635

Matthew Montano
15 5335

Patricia Sanchez
15 11300

Kelly Thoesen
15 3521

Benjamin Thurston
15 1718

Delvin Wood
15 4225

Steven Woodall
15 2728

Dale Zschiesche
15 2735

LabNews locations

Lab News is available in news racks at 24 locations throughout the Labs. A digital version of *Lab News* continues to be available on Tech Web as well as on Sandia.gov.

1. Bldg. 802, elevator lobby
2. Bldg. 810, east lobby
3. Bldg. 822, south entrance
4. Bldg. 858 EL, lobby
5. Bldg. 880, Aisle D, north lobby
6. Bldg. 892, lobby
7. Bldg. 894, east entrance, lobby
8. Bldg. 898, east lobby
9. Bldg. 887, lobby
10. Bldg. 878, lobby
11. Bldg. 836, lobby
12. Bldg. 831/832 north lobby
13. Bldg. 861, Cafeteria lobby
14. Bldg. 870, lobby
15. Bldg. 701, lobby
16. IPOC, lobby
17. CGSC, lobby
18. CRSI, lobby
19. M.O. 308, lobby
20. Bldg. 960, lobby
21. Bldg. 962 (TA III), lobby
22. Bldg. 6585 (TA V), lobby
23. Bldg. 905, lobby
24. 800(A), outside of Vicki's

SANDIA CLASSIFIED ADS

Due to the winter shutdown, the deadline to submit a classified ad for the Jan. 8, 2016, Lab News will be Wednesday, Dec. 23, at noon.

MISCELLANEOUS

FIREWOOD RACKS, 2, 3-ft. diameter hoop, $5 ea.; 2 men's bicycles, 26-in., $50/both. Horton, 883-7504.

COMPUTER DESK, 2 rolling office chairs, $75/all; futon, $50; washer, gas dryer, good working condition, $100 ea. or $175/set; East Mountains, you pick up. Baswell, 805-910-9653.

BABY FURNITURE SET, 3-pc., espresso-colored, dresser, changing table, convertible crib/toddler/twin bed, $225 OBO. Brito, 505-382-4643.

BED FOUNDATION, queen, adjustable, metal frame, Select Comfort foundation/platform, w/o mattress, $50 OBO. Roesch, 899-9145.

LONG-ARM QUILTING MACHINE, ABM, 18-in. throat, stitch regulator, 10-ft. frame, $8,500. Smith, 505-414-4161.

BROADWAY SERIES TICKETS, Popejoy, 'Once' (March 13), 'Newsies' (June 26), 2 balcony seats, $30 ea. Witt, 991-1878.

PLEXIDOOR, small animal 'wall' door, new-in-pkg., retail $300, asking $150. Fondren, 463-5572.

SMITH SUPERSHOP, similar to ShopSmith, but more heavy-duty, all accessories included, new $2,600, make offer. Rodacy, 505-293-2668.

HAY, high-grade Timothy, horses hay, from northern New Mexico, $10/bale, delivered. Lopez, 505-321-3385.

APPLE iPAD 2, w/charger, 16GB memory, WiFi, Bluetooth, excellent condition, $125 OBO. Carpenter, 382-4177.

LOVESEAT, w/2 pillows, 62" X 38" X 37", Google 'Collin spa loveseat' for photos, like new, $250. Kraus, 275-1005.

PREAMPLIFIER, Audio Research, Reference One, $3,200; DAC3 MK2, $1,400; low hours, mint condition. Miller, 281-3655.

DENTAL WATER JET, cordless, portable, Capitano Innofit of Italy, model INN 010, w/user manual, brand new, takes 2 AA batteries, $15. Wagner, 505-504-8783.

TV, Mitsubishi, WD-65738, 65-in., full 1080p, 3D rear-projection, internet, low lamp hours, ~2,800, $250 OBO. Lujan, 299-2218.

HAWAII TIMESHARE, 1 wk., studio, Oahu, lifetime in Hawaii at the Royal Kuhio, $500. Felix, 573-0595.

TIMESHARE/CONDO, 12/4-12/6, 2 nights, 1 bdr., Durango, take kids on Polar Express, reduced, $150 total. Fernandez, 505-238-4722.

VENT-FREE HEATERS, 30,000- & 20,000-Btu, propane (or gas), thermostat, ODS, blower & base, $250 & $200. Marron, 345-4006.

CIRCULAR SAW, Skilsaw, 7-1/4-in., 13 amps, rip/crosscut & masonry blades, like new, $45. Dockerty, 828-0745.

GoPRO, Hero 3, white, accessories, text or call for details, $200. English, 505-205-6853.

COUCH, $250; coffee table, end tables, $700; lounge chair, $150; food processor, $50. Wymer, 507-2501.

AQUARIUM, freshwater, 55-gal., w/stand, heater, filter, chemicals, 5 fish, free. Cutler, 505-350-0598.

CHRISTMAS GARLAND, w/lights, 4 strands, 100-in., $20 ea.; many other assorted decorations, excellent condition, necessary to downsize. Drebing, 293-3335.

AQUARIUM, 45-gal., complete set, $400. Dickman, 505-828-4980.

THREE-SECTIONAL COUCH, La-Z-Boy, w/2 recliners, brown cloth, very good condition, $500. Bertsch, 873-0925.

CARRIER, Thule, 4 bikes, 4 pairs of skis, w/locks, for 2-in. receiver hitch, $200. Shaw, 505-980-7491.

RV TOW BAR, Falcon 5250, paid $569, asking $375; tow wiring kit, $190, lounge & folding chairs, BBQ, water pump, lots of other RV camping items. Garcia, 554-2690.

How to submit classified ads

DEADLINE: Friday noon before week of publication unless changed by holiday.

Submit by one of these methods:

- **EMAIL: Michelle Fleming (classads@sandia.gov)**
- **FAX: 844-0645**
- **MAIL: MS 1468 (Dept. 3651)**
- **INTERNAL WEB: On internal web homepage, click on News Center, then on *Lab News* link, and then on the very top of *Lab News* homepage "Submit a Classified Ad."**

If you have questions, call Michelle at 844-4902.

Because of space constraints, ads will be printed on a first-come basis.

Ad rules

1. Limit 18 words, including last name and home phone (If you include a web or e-mail address, it will count as two or three words, depending on length of the address.)
2. Include organization and full name with the ad submission.
3. Submit ad in writing. No phone-ins.
4. Type or print ad legibly; use accepted abbreviations.
5. One ad per issue.
6. We will not run the same ad more than twice.
7. No "for rent" ads except for employees on temporary assignment.
8. No commercial ads.
9. For active Sandia members of the workforce, retired Sandians, and DOE employees.
10. Housing listed for sale is available without regard to race, creed, color, or national origin.
11. Work Wanted ads limited to student-aged children of employees.
12. We reserve the right not to publish any ad that may be considered offensive or in bad taste.

TRANSPORTATION

'04 MITSUBISHI OUTLANDER, AWD, sunroof, roof rack, bright blue, 120K miles, good condition, $3,500 OBO. Akinnikawe, 512-289-9327.

TAURUS, AM/FM/CD/XM Sirius, Sync for hands-free phone, 24K miles, excellent condition, $14,500 OBO. Sensi, 299-3958.

'15 HONDA CRZ HYBRID, white, 10K highway miles, perfect condition, MSRP $24,733, asking $18,999. Keegan, 505-238-3638.

'05 TOYOTA TUNDRA SR5, double cab, 4x4, AT, TRD pkg., tow pkg., locking bed tool box, silver/grey cloth, 170K miles, very good condition, below book, $10,500. Dwyer, 271-1328.

'10 HYUNDAI GENESIS, coupe, 2-dr., premium sunroof, black, excellent interior/mechanical condition, 46K miles, $13,000 OBO. Chavez, 720-339-3544.

'10 FORD EDGE SPORT, leather/suede power seats, Bluetooth, 20-in. wheels, 98K miles, $14,700. Gonzalez, 505-463-5057.

'11 SHELBY GT500 MUSTANG, supercharged, 6-spd., gray, SVT performance pkg., Ford Premium Care warranty, $41,000 OBO. Johnson, 505-720-0994.

'15 FIAT ABARTH, brand new, 1,100 miles, like new, expecting baby, need 4-dr., $16,800 OBO. Martin, 623-687-7673.

'08 TOYOTA TACOMA, TRD pkg., 4x4, 4-dr., 1 owner, new tires, maintenance records, 85K miles, $22,500. Smith, 505-903-0911.

RECREATION

COLEMAN POPUP TRAILER, sleeps 8, large storage compartment in front, rear hitch, heater works great, $4,000. Clements, 865-3993.

REAL ESTATE

TUSCAN-STYLE HOME, gated community, mountain views, on Bosque, next to bike trails, must see, MLS#852234. Gonzales, 505-480-7524.

2 ACRES, The Woodlands, Sedillo Hill, great views, flat lot, easy-to-build on, all utilities underground, paved roads, 20 mins. to SNL, $120,000. Duncan, 505-835-4243.

3-BDR. HOME, 3 baths, 1,507-sq. ft., stainless appliances, refrigerated air, courtyard & casita, spacious patio/yard, 2035 Mountaineer, $235,000. Gayer, 218-1361.

2.58 ACRE LOT, Edgewood, all utilities available, w/natural gas, beautiful vistas, near schools, $60,000. Sanchez, 980-3536.

SANDIA PARK, gorgeous building lots, w/utilities, 2 & 4 acres available, new road & fence, $120,000/$160,000, owner financing available. Mihalik, 505-281-1306.

3-BDR. HOME, 2-1/2 baths, 1,813-sq. ft., Four Hills North, 11 mins. to Eubank gate, cul-de-sac, many upgrades, MLS#842449, $270,000. Mirabel, 270-0074.

4-BDR. HOME, 2 baths, 2,158-sq. ft., hardwood floors, large storage room, spacious backyard, MLS#851332, $138,000. Thomason, 505-506-6722 or 505-944-6544.

3-BDR. HOME, 1-3/4 baths, 1,990-sq. ft., 2 living areas, 2-car garage, large lot, Constitution/Wyoming, MLS#853350, $166,900. Fullmer, 505-730-7474.

2-BDR. HOME, 1 bath, near base, w/storage shed & workshop, needs some TLC, 913 La Veta Drive NE, $125,000. Kemp, 505-263-0039.

LARGE MOBILE HOME LOT, Los Lunas, ready for single-wide mobile home, cash only, $35,000. McDonald, 505-833-0332.

WANTED

GOOD HOME, Maine Coon cat, loving, 2 yrs. old, great w/kids & dogs. Tapia, 280-8888.

STEREO, old school component rack system, 70's-80's-style, good working order, speakers, tape, phono tuner, CD. Wells, 293-0468.

CAREGIVER, for 12-hrs., 5 days a wk/, East Mountains, for elderly male stroke victim. Dotson, 281-9057.

SACNAS Conference draws 3,800

Sandra Begay-Campbell: Bridging science, culture, and community

Motivating an audience of nearly 3,800 students and career professionals toward positions of science leadership, Sandia engineer Sandra Begay-Campbell (6124) spoke at the 2015 SACNAS (Society for Advancement of Chicanos, Hispanics, and Native Americans in Science) National Conference in Washington, D.C., on Oct. 30. Sandra was invited as a featured speaker to help inspire the next generation of scientists and engineers to build careers that integrate science, culture, and community.

(Photo by Lisa Helfert/SACNAS)

Recent Retirees

New Mexico photos by Michelle Fleming

Ron Lipinski
37 6223

Bob Chambers
30 1526

Doug Mangum
30 5350

Richard (RD) Mackoy
29 2133

Bonnie Apodaca
27 10000

Ron Maes
26 2155

Terry Reser
17 3300

Mary Horvath
10 4128

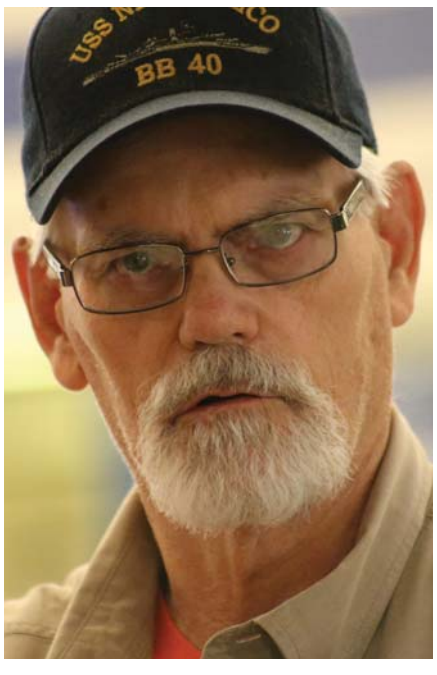
Honoring Sandia's veterans

Honoring soldiers and their families who have served the nation, including the 1,059 veterans at the Labs, Sandians packed the Steve Schiff Auditorium on Nov. 9, for Sandia/New Mexico's Veterans Day event. Hosted by Div. 4000 VP Mike Hazen and the Military Support Committee, the celebration included a coin ceremony for veterans and performances by the Sandia Singers. The event highlighted the 100th anniversary of the US Navy Reserve. Keynote speaker Rear Adm. Priscilla B. Coe, deputy chief of the Navy Reserve Dental Corps, presented "A Tribute to Veterans: Being There Matters."

KEYNOTE SPEAKER Rear Admiral Priscilla B. Coe, deputy chief of the Navy Reserve Dental Corp, greets World War II Army veteran Alan B. Putnam.

WOUNDED WARRIOR Career Development Program member Ian M. Gardner (5437) with son R.J.

Photos by Lonnie Anderson



DEPUTY LABS DIRECTOR & Executive VP for Mission Support Kim Sawyer, right, presents a plaque to keynote speaker and special guest Rear Adm. Pricilla Coe.

HONORING THOSE WHO SERVED — From left, Div. 4000 VP Mike Hazen, keynote speaker Rear Adm. Priscilla Coe, World War II veteran Alan Putnam, Executive VP and Deputy Laboratories Director Kim Sawyer, Div. 5000 VP James Peery, and Clark Highstrete (1729) at the Sandia/New Mexico Veterans Day celebration.